INSTALLING A Radiant Wall

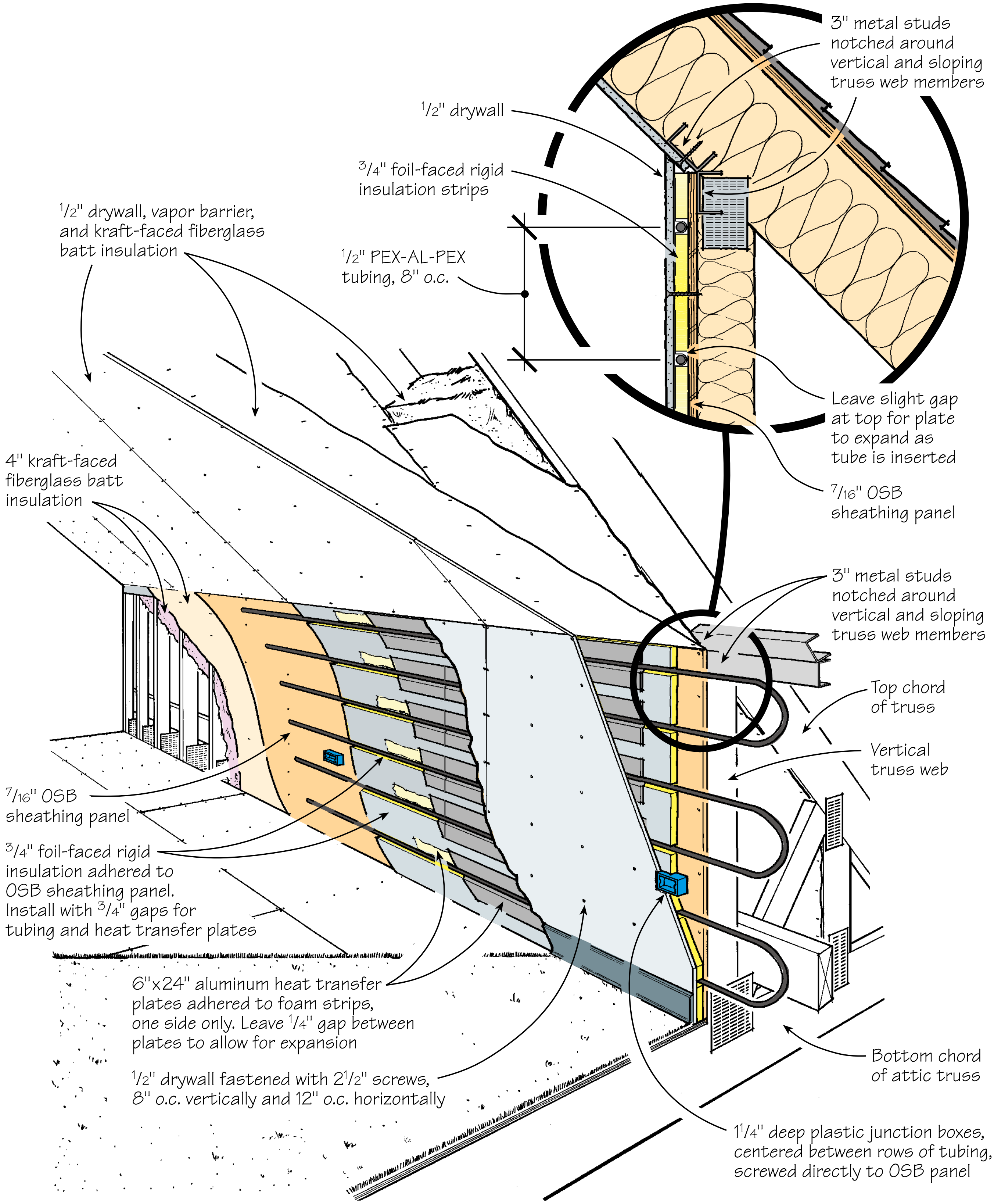
You can use walls and ceilings to provide warmth with this innovative variation on radiant floor heating

by John Siegenthaler

In recent years, hydronic radiant floor heating has become increasingly common throughout the U.S. It's widely viewed as one of the most comfortable forms of heating in kitchens and baths, especially where tile floors are involved. As the technology has grown more popular, radiant heating is being used more and more in other rooms of the house as well.

Radiant floor heating does have its limitations, however. Let's say a heated floor gets covered with a heavy carpet and pad: It's like throwing a blanket over a radiator; the floor can't release heat into the room fast enough. Full-thickness solid wood flooring can also act as an insulator. The same is true where much of the floor gets covered with furniture, cabinets, or other objects that restrict heat output.

Inside a Radiant Wall



After screwing the OSB sheathing to the attic truss webs, the author used contact cement to fasten strips of foam insulation to the OSB. U-shaped aluminum heat transfer plates were then cemented to the foam boards, but only along one side to allow the plates to expand as they heat up. Chalklines snapped on the drywall ensured that no screws penetrated the PEX tubing.

If the designer of a radiant system fails to account for floor coverings, the customer may complain that the room is too cold. Cranking up the water temperature in the tubing is generally not a good way to remedy this situation, because the exposed floor areas may get uncomfortably warm. Also, temperatures above 85˚F increase stress on wood floors, possibly leading to excessive shrinkage and gaps between boards. In fact, the warranties of some flooring products restrict surface temperature to 85˚F.

Advantages of Radiant Walls

When radiant system designers take floor coverings into account, they may find that some rooms require more heat than the floor alone can provide. This supplemental heat could be provided by baseboard convectors or panel radiators, but from an aesthetic viewpoint, these compromise the invisible look of radiant floor heating. Why not use a drywall surface — a wall or even a ceiling — as a heat source? One scenario would be to use the floor to provide all the heat during partial load conditions, with the heated wall operating as necessary during very cold weather, or to speed up room temperature recovery following a setback period. Such a system could be controlled with a standard two-stage thermostat. Another scenario would be to use the wall as the sole radiant panel for the room.

Recently, Harvey Youker of Undersun Construction and I had the opportunity to design and build a radiant wall using a 4-foot-high by 31-foot-long kneewall. The technique would also work well in a room with a chair rail 36 to 40 inches above the floor, which could provide a natural break between the thicker heated wall below and a standard-thickness wall above, eliminating the need to shim out the upper portion of the wall. This would also deliver the radiant heat into the lower, occupied portion of the room, where it provides the most comfort. (It's also less likely that occupants will drive nails into the lower portion of the wall to hang pictures.) A chair rail could also provide a clean transition line in a retrofit situation.

A heated wall actually has certain advantages over a heated floor. For one thing, drywall isn't subject to the 85˚F surface temperature limit often imposed on floors, so it's possible to get more heat from a heated wall than from a heated floor of the same size. This, and the fact that 1/2-inch drywall has relatively low thermal mass, make a radiant wall useful in areas that require fast recovery time. A heated wall would be well-suited for passive solar buildings, for example, which often have large, quickly changing heat gains and losses.

To create the radiant wall surface, the author first sheathed the kneewall of attic trusses with OSB. Strips of foil-faced foam were then adhered to the OSB, with 3/4-inch gaps left to accept the aluminum heat-transfer plates and PEX tubing.

A paint roller is used to apply contact adhesive to foil-faced foam before mounting aluminum heat-transfer plates. Adhesive is used only on one edge of each strip to allow for thermal movement.

Just as with floors, the output of a radiant wall will be affected by objects placed against it. Before you commit to a wall heating system, find out if the owner is planning to line the wall with bookcases, an entertainment center, upholstered furniture, and so forth. Some coverage is probably acceptable as long as it's accounted for in the design.

Components

The system that Harvey and I installed used common materials. For hydronic tubing, we used 1/2-inch Alumipex (Weil-McLain, 500 Blaine St., Michigan City, IN 46360; 800/368-2492; www.weil-mclain.com). Unlike standard PEX tubing, which is all plastic, this PEX-AL-PEX tubing has a thin layer of aluminum sandwiched between inner and outer layers of cross-linked polyethylene. We chose it because its rate of thermal expansion and contraction is much lower than that of standard PEX, reducing the possibility of "ticking" sounds as the system warms up and cools down.

The tubing snaps into 6x24-inch aluminum heat transfer plates, also from Weil-McClain, which have a semicircular groove down their centerline that wraps around the tubing. (These are the same plates used in radiant floor applications.) The high conductivity of the aluminum conducts heat away from the tubing and spreads it out across the surface to be heated.

The plates mounted over strips of 3/4-inch Thermax foil-faced polyisocyanurate board, spaced to accommodate the tubing. The rigid foam adds about R-5.2 to the wall insulation, helping direct heat into the room. Although the aluminum facing is only about 0.001 inch thick, it helps conduct heat away from the tubing and disperse it across the wall surface. And because the foam has a very low thermal mass, it allows the wall to heat up quickly when warm water starts circulating through the tubing. (Incidentally, we checked with the rigid foam manufacturer to make sure that it would remain dimensionally stable and not outgas when heated. It's actually rated for service at temperatures up to 250˚F. The highest temperature we expected it would see in this application was around 140˚F.)

Under the foam board, we used standard 7/16-inch OSB, with 4 inches of fiberglass insulation behind that. The system described here can be used on either exterior or interior partition walls. In an exterior wall, the total R-value of the insulation behind the aluminum plates should be at least 50% greater than the R-value ordinarily specified for a standard unheated wall in a given climate.

In an interior partition, you can probably leave the fiberglass back-side insulation out altogether. In floor heating applications, we usually use a ratio of 10:1, downward to upward R-value as a guideline. The greater this ratio, the more heat is directed into the room. Even without back-side insulation added to the wall system, the foam strips and OSB together constitute about R-5.5. Since the 1/2-inch drywall has an R-value of about 0.5, the back-side to room-side R-value ratio is 11:1, slightly better than the 10:1 ratio used in floor heating design. Keep in mind that back-side losses on interior walls are also usually heat gains to other rooms. Also, a convective air current will be set up within any uninsulated stud cavities behind the heated wall. Make sure there are no holes or notches in the top plate where the warm air can escape.

I've calculated that the radiant wall described here will deliver about 1.4 Btu/hr./sq.ft. for every degree the wall surface temperature exceeds the room air temperature. For example, if the mean wall surface temperature is 95˚F and the room temperature is 68˚F, the heat output should be about (95-68) x 1.4 = 37 Btu/hr/sq. ft.

Although many components in this wall are capable of operating at relatively high temperatures, the surface of the drywall should not be allowed to exceed 120˚F. At higher temperatures, the drywall joints might discolor or hairline cracks might appear. Based on theoretical models of the wall's performance, I suggest limiting water supply temperatures to about 140˚F.

Installation Is Straightforward

The first step was to provide a nailer between the trusses where the vertical and sloped webs meet. To avoid the tedious process of installing solid wood blocking, we used 2x3 metal studs turned on edge, notching the flanges at every truss web with metal snips (see illustration, page 2).

After insulating the stud cavities with high-density fiberglass batts, we sheathed the kneewall with 7/16-inch OSB to provide a smooth, strong substrate for the rest of the system. We then ripped 7 1/4-inch by 8-foot strips from 4x8 sheets of 3/4-inch foil-faced polyisocyanurate board. We snapped horizontal chalk lines every 8 inches up the wall, starting 3 5/8 inches above the floor. These lines marked the top edge of each foam strip.

We bonded the foam strips to the OSB with Franklin solvent-based contact cement, using a paint roller to apply the adhesive to both surfaces. (Again, we verified that the adhesive would not lose strength or pose outgassing problems at elevated temperatures.) We used a couple of 3/4-inch wood spacer blocks to maintain a consistent gap between the strips as we pressed them into place.

At this point, we mounted three 1 1/4-inch-deep plastic receptacle boxes directly on the OSB, centered between rows of tubing. The Romex runs out the back of the boxes into the wall cavity. The 1 1/4-inch depth allowed the boxes to finish flush with the drywall.

Tubing and final finish. Next we installed the aluminum heat transfer plates, again with contact adhesive. We used a 3-inch paint roller to apply the cement to only one side of the plate and the matching face of the foam board. Bonding only one side of the plate would allow the plate to expand and contract with changes in temperature. We also left a 1/4-inch gap between adjacent plates to allow for expansion, and held the plates back about 4 inches from the junction boxes to avoid heating the receptacles.

Installing the tubing was a matter of snapping the straight runs of tubing into the grooved aluminum plates, then making return bends by hand at the ends of the wall. In laying out the tube, we made sure that supply and return ends of the circuit fell at the same end of the wall, to minimize tubing "leaders" that are not part of the heated wall.

The final step was to install the 1/2-inch drywall. We snapped guide lines half way between the rows of tubing and drove the screws to the line as usual. Using the OSB as a backer sheet, we placed 2 1/2-inch screws every 8 inches vertically and every 12 inches horizontally. The generous screw pattern ensures that the drywall is sucked in tight against the aluminum plates for good heat transfer. We taped and painted the wall as usual.

Return bends in the 1/2-inch PEX-AL-PEX tubing were easily formed by hand.

How It All Works

An oil-fired boiler is the heat source for the wall (as well as the other hydronic systems in the building). A variable speed injection mixing system is used to control the wall's supply water temperature. The mixing system can be configured for either a fixed water temperature or a water temperature that increases as outdoor temperature drops. To date, I've operated the wall at a fixed supply temperature of 125˚F.

The wall has been through one complete heating season, with positive results. From a startup temperature of 60˚F, heat output is evident in about 10 minutes. The wall appears to reach steady operating conditions about 30 minutes after a cold start. The system operates silently, without any expansion sounds following cold starts. Part of the credit goes to the PEX-AL-PEX tubing, which has an expansion rate very close to that of the aluminum plates. We were also careful to leave an expansion space between the return bends and the end walls of the room; this prevents binding and the subsequent expansion "ticks" often heard in hydronic systems.

John Siegenthaler *owns Appropriate Designs in Holland Patent, N.Y., and is author of* Modern Hydronic Heating *(Delmar, 800/347-7707). Thanks to* ***Harvey Youker*** *for assisting with this article.*